Revista Mexicana de Ortodoncia

Vol. 4, No. 1 • January-March 2016

pp e30–e34

ORIGINAL RESEARCH

Bolton's index efficacy with manual vs digital measurements

Eficacia del índice de Bolton por medición digital vs manual

Raúl Alejandro Aude Díaz,* Wulfrano Sánchez Meraz,§ Jairo Mariel Cárdenas,‖ Francisco Javier Gutiérrez Cantú,‖ Humberto Mariel Murga‖

ABSTRACT

Objective: To assess whether there is a variation in the values of Bolton index, making measurements manually or digitally. **Material and methods:** 70 pairs of study models were analyzed and measured on two occasions: one using a compass and a millimeter rule, and the other using an electronic vernier. **Results:** No statistically significant difference was found between the two measurements. **Conclusion:** Both ways to perform mesiodistal dental measurements are good choices for Bolton analysis.

RESUMEN

Objetivo: Evaluar si existe una variación en la medición del índice Bolton, realizando las medidas de manera manual y de manera digital. **Material y métodos:** Se analizaron 70 pares de modelos de estudio; los cuales fueron medidos en dos ocasiones; mediante el uso de un compás y una regla milimetrada, y mediante el uso de un vernier electrónico. **Resultados:** No se encontró diferencia estadísticamente significativa entre ambas mediciones. **Conclusión:** Las dos formas de realizar la medición dental mesiodistalmente son buenas opciones para el análisis de Bolton.

Key words: Mesiodistal width, bolton analysis, measurement.
Palabras clave: Ancho mesiodistal, análisis de Bolton, medición.

INTRODUCTION

The size ratio of maxillary and mandibular teeth, specifically mesiodistal dental width, is an important aspect in diagnosis and treatment planning for an individual. Discrepancies in tooth size should be identified early during diagnosis and initial treatment in order to obtain an ideal result. Tooth size relationships represent a valuable diagnostic tool that may provide a prediction of the results of treatment and may also limit the need for diagnostic configurations in complex cases.[1-3]

Wayne A. Bolton in 1958 formulated a total analysis and an anterior analysis to estimate the discrepancy in the size of the teeth by measuring and comparing the mesiodistal widths of the dental arches including the distal surfaces of the first molars, as well as the anterior segment (from canine to canine). This analysis is often referred to as «analysis of Bolton», for he investigated the relationship between the mesiodistal diameters of the upper and lower tooth crowns on the basis of 55 patients with excellent occlusion, including 44 treated with orthodontics (without extractions) and 11non-treated subjects.[4-8]

Bolton introduced two indexes. The anterior Bolton index is obtained by dividing the mesiodistal size of the 6 mandibular anterior teeth (canine to canine) by the mesiodistal size of the 6 upper anterior teeth; the total Bolton index is obtained by dividing the mesiodistal size of the 12 mandibular teeth (first molar to first molar) by the mesiodistal size of the 12 maxillary teeth.[9]

However, extrinsic factors such as sexual dimorphism, race and ethnic variation, type of malocclusion, anterior teeth inclination, incisal edge and arches thickness and smile may affect this proportion which usually requires adjustments in the anterior relationship as Bolton described. In other words, a high or low Bolton ratio does not necessarily reflect the actual discrepancy and an ideal index does not guarantee an ideal occlusion.[10]

Through this research it is sought to know if there is a variation in the total Bolton index or the anterior Bolton index by performing the mesiodistal width

* Student of the Orthodontics and Dentomaxillofacial Orthopedics Post-graduate Program.
§ Head of the Orthodontics and Dentomaxillofacial Orthopedics Post-graduate Program.
‖ Professor at the Stomatology Faculty.

Autonomous University of San Luis Potosi.

See related content at doi: http://dx.doi.org/10.1016/j.rmo.2016.03.081

measurement of each tooth manually (through the use of a compass and rule in millimeters) or using an electronic Vernier.

MATERIAL AND METHODS

A comparative study was conducted in which 70 pairs of study models were analyzed. The models were obtained from patients who attended the Post-graduate Orthodontics and Dentomaxillofacial Orthopedics Program of the UASLP of whom 50% were female patients and 50% male patients.

The criteria for model selection were: 1) permanent dentition from first molar to first molar, 2) good quality of the casts (models without negative or positive bubbles that may alter the mesio-distal dental diameter), 3) models that do not present teeth with extensive restorations that may modify mesiodistal dental width.

In each model the dental crowns were measured mesiodistally from first molar to first molar. Such measurement was performed on two occasions: the first through the use of a compass and a rule in millimeters, the second using a digital caliper *(Figures 1 and 2)*.

The sum of the diameters of the lower teeth was divided by the sum of the diameters of the upper teeth and the result was multiplied by 100 to obtain the total Bolton index. The sum of the diameters of the anterior teeth, from canine to canine, was also obtained and then the sum of the lower was divided by the upper and the result multiplied by 100 to obtain the anterior Bolton index.[3,4]

The statistical analysis was obtained using the MINITAB software (version 16). The normality of the variables was analyzed and a «t» test was performed to determine the significance.

RESULTS

No significant differences were found in the total or the anterior Bolton index when comparing digital measurement vs manual measurement or between the group of male patients and the group of female patients.

Through the manual measurement a total Bolton index of 0.91762 was obtained; with a standard deviation of 0.02527; while digitally, a total Bolton index of 0.91931 was obtained with a standard deviation of 0.02060 resulting in a difference of 0.00169 between both. An anterior Bolton index 0.78073 was obtained manually with a standard deviation of 0.02960 and digitally it resulted in 0.78491 with a standard deviation of 0.02477 thus having a difference of 0.00418 *(Table I)*.

In the female group, the Bolton total index difference was -0.00535, while that of the anterior Bolton index was -0.00609 *(Table II)*. For the male group the differences were of 0.00198 and -0.00228 in the total and anterior Bolton, respectively *(Table III)*.

In tables 4 and 5 an analysis by dental organ is shown. In *table IV* a comparison is made of the data obtained according to the type of measurement while *Table V* shows the comparison of the «P» values

Figure 1. Measurement of the mesio-distal width using a compass and a ruler.

Figure 2. Mesiodistal width measurement using a digital caliper.

Table I. Descriptive statistics for anterior and total Bolton.

Variable	N	Mean	Standard	S.D.	Minimum	Maximum
Total Bolton (manual)	70	0.91762	0.00302	0.02527	0.86408	0.96970
Total Bolton (digital)	70	0.91931	0.00246	0.02060	0.87507	0.96388
Bolton Difference (total)	70	-0.00169	0.00332	0.02778	-0.06151	0.06901
Anterior Bolton (manual)	70	0.78073	0.00354	0.02960	0.70370	0.84946
Anterior Bolton (digital)	70	0.78491	0.00296	0.02477	0.73535	0.84448
Bolton difference (anterior)	70	-0.00418	0.00378	0.03165	-0.09256	0.07397

Table II. Descriptive statistics for the female group.

Variable	N	Mean	Mean of the standard error	S.D.	Minimum	Maximum
Total Bolton (manual)	35	0.91670	0.00396	0.02340	0.87179	0.96939
Total Bolton (digital)	35	0.92205	0.00336	0.01986	0.88404	0.95984
Bolton difference (Total)	35	-0.00535	0.00414	0.02451	-0.06151	0.05049
Anterior Bolton (manual)	35	0.78147	0.00461	0.02726	0.073404	0.84946
Anterior Bolton (digital)	35	0.78756	0.00406	0.02399	0.74774	0.83999
Bolton difference (anterior)	35	-0.00609	0.00551	0.03261	-0.09256	0.06802

Table III. Descriptive statistics for the male group.

Variable	N	Mean	Mean of the standard error	S.D.	Minimum	Maximum
Total Bolton (manual)	35	0.91854	0.00462	0.02732	0.86408	0.96970
Total Bolton (digital)	35	0.91656	0.00359	0.02125	0.87507	0.96388
Bolton Difference (total)	35	0.00198	0.00518	0.03062	-0.05892	0.06901
Anterior Bolton (manual)	35	0.77999	0.00543	0.03215	0.070370	0.84783
Anterior Bolton (digital)	35	0.78226	0.00433	0.02560	0.73535	0.84448
Bolton difference (anterior)	35	-0.00228	0.00524	0.03100	-0.08889	0.07397

obtained in each of the teeth according to the gender *(Tables IV and V)*.

DISCUSSION

In the literature regarding mesiodistal dental width, it has been found that currently the measurement is done mainly through the use of a digital vernier,[1,3,-5,7,8,11-15] and even there is research in which the measurements are taken using three-dimensional images scanned from a physical model.[16-19] Comparisons have been made between these forms of measurement but there are no comparative studies using manual measurement with a compass, a method used by Dr. Bolton in his study[1] and in the Orthodontics Post-graduate Program at the Autonomous University of San Luis Potosi.

The difference in the mesiodistal dimension found in the study of K. Bootvong between the measurement obtained with a digital caliper and the one obtained through a computerized virtual model was not statistically different from zero. By obtaining a similar result in our study which compared manual measurement with a compass against the measurement obtained with a digital caliper, the possibility of obtaining measurements through three different methods without a significant difference is shown. We suggest that in the future a comparative study between these three methods of measurement should be performed.[17]

HariPrasad in his study indicated that the sharp ends of a digital caliper might help in obtaining measurements with greater accuracy,[12] while in our research we considered that the compass allowed us to fit the tips more easily, especially in cases where there was overcrowding or rotations which made the measurements difficult. The largest flaw that we observed in this method was when transporting the measurement obtained with the compass to the millimeter rule, since it was not feasible to obtain exact figures as it is done with a digital caliper.

Table IV. Descriptive statistics per tooth.

		Mean		Mean of standard error		S.D.		Minimum		Maximum	
Tooth	N	Digital	Manual	Digital	Manual	Digital	Manual	Digital	Manual	Digital	Manual
16	70	10.346	10.429	0.0566	0.0654	0.474	0.547	9.21	9.5	11.48	12
15	70	7.08	7.0571	0.0646	0.0709	0.5401	0.5931	6.19	6	8.98	8
14	70	7.5046	7.4929	0.0569	0.0615	0.4761	0.5142	6.54	6.5	8.64	8.5
13	70	8.282	8.2786	0.0672	0.0792	0.5621	0.6629	7.08	7	9.64	10
12	70	7.2511	7.1357	0.0751	0.0733	0.628	0.6134	5.77	6	8.32	8.5
11	70	8.8944	8.9643	0.0702	0.0847	0.5873	0.7088	7.49	7.5	10.17	10
21	70	8.8769	8.9929	0.0727	0.0823	0.6081	0.6889	7.23	7.5	10.33	10
22	70	7.2404	7.1857	0.0702	0.0756	0.5876	0.6323	5.91	6	8.47	8.5
23	70	8.2806	8.2786	0.0668	0.0772	0.5588	0.6463	7.08	7	9.59	10
24	70	7.5177	7.5071	0.0548	0.0615	0.4584	0.5142	6.54	6.5	8.64	8.5
25	70	7.0677	6.9571	0.0624	0.0665	0.5223	0.5565	6.19	6	8.11	8
26	70	10.363	10.494	0.0574	0.0655	0.48	0.548	9.21	9.5	11.64	12
46	70	11.341	11.407	0.0729	0.0877	0.61	0.734	10.01	10	12.48	13
45	70	7.4373	7.4357	0.0608	0.0674	0.5086	0.5642	6.17	6	8.43	8.5
44	70	7.4199	7.4243	0.06	0.059	0.502	0.4933	6.27	6.2	8.42	8.5
43	70	7.1996	7.1714	0.0657	0.0719	0.5501	0.6012	6.09	6	8.45	8.5
42	70	6.3811	6.3	0.0651	0.0639	0.5447	0.5343	5.32	5	8.92	8
41	70	5.6039	5.5643	0.0479	0.0538	0.4004	0.4498	4.71	4.5	6.5	6.5
31	70	5.5629	5.5714	0.047	0.0531	0.3931	0.4447	4.71	4.5	6.5	6.5
32	70	6.3153	6.2786	0.0513	0.059	0.4292	0.4937	5.32	5	7.51	7.5
33	70	7.247	7.2214	0.0679	0.0695	0.5681	0.5813	6.01	6	8.53	8.5
34	70	7.43	7.4071	0.057	0.0596	0.4772	0.4985	6.27	6.5	8.72	8.5
35	70	7.4227	7.35	0.0603	0.0613	0.5046	0.5132	6.17	6.5	8.49	8.5
36	70	11.374	11.486	0.0741	0.0801	0.62	0.67	10.29	10	12.74	13

Goose suggested that the mesiodistal diameter should be located between the contact points of the dental crown with the neighboring teeth in cases of normal occlusion. While in cases of malocclusion, the crown position in which the contact points would have been in normal occlusion are used. In the event of a rotated tooth we have to obtain the mesiodistal measurement diagonally. If the teeth are lingually inclined we have to use the lingual mesiodistal measurement.[12] In this study we took into consideration the abovementioned suggestions at the time of performing the measurements in order to avoid errors which could affect our results.

The results obtained in the individual tooth measurement vary in relation to the values obtained by other authors.[1-3,5,9,12-14,16] These values differ mainly due to the different populations in which each study takes place. Our research shows values obtained from a Mexican population.

In our study there was no statistically significant difference between the mesiodistal width measurement of teeth of women or men, obtaining in both cases > 0.05 «P» values. The same result was obtained by Trehan et al who compared the results obtained in their investigation according to gender.[1]

CONCLUSIONS

Although the use of a digital caliper may be more accurate than the measurement obtained with a compass and a rule by showing the obtained measurements with more decimals, it was demonstrated by this study that the statistical difference is not significant. We therefore consider that a digital caliper is optional equipment for performing this type of measurements since the orthodontist is trained to do so without it and the same results are obtained.

It is recommended to perform more research on this topic comparing larger samples and adding different measurement methods such as measurements in virtual models. A larger sample will provide further knowledge in regard to difference by sex, race and even more variables may be added such as variations by malocclusions type among others.

ACKNOWLEDGEMENTS

This research was supported by the Orthodontics and Dentomaxillofacial Orthopedics Specialty of the Autonomous University of San Luis Potosí, Mexico.

Table V. «p» value in males, females and in the total sample.

Tooth	Male (manual/digital)	Female (manual/digital)	Total (manual/digital)
16	0.339	0.701	0.342
15	0.587	0.625	0.812
14	0.952	0.893	0.889
13	0.65	0.886	0.974
12	0.592	0.3	0.273
11	0.682	0.605	0.527
21	0.533	0.36	0.293
22	0.924	0.375	0.597
23	0.0807	0.832	0.984
24	0.978	0.842	0.989
25	0.56	0.259	0.228
26	0.107	0.628	0.137
46	0.287	0.862	0.562
45	0.582	0.543	0.986
44	0.576	0.661	0.958
43	0.98	0.638	0.773
42	0.517	0.55	0.375
41	0.703	0.483	0.583
31	0.768	0.835	0.904
32	0.975	0.493	0.639
33	0.731	0.956	0.793
34	0.745	0.475	0.782
35	0.73	0.038	0.399
36	0.27	0.73	0.306
Total	35	35	70

REFERENCES

1. Trehan M, Agarwal S, Sharma S. Applicability of Bolton's analysis: a study on jaipur population. *Int J Clin Pediatr Dent*. 2012; 5 (2): 113-117.
2. Tayyab M, Zakir S, Hussain U, Jehan R, Nasrullah Z. Bolton discrepancies among different classes of malocclusion in peshawar population. *Pakistan Oral & Dental Journal*. 2014; 34 (4): 647-650.
3. Anil S, Monika M. Bolton analysis of Himachali Ethnic Population. *Indian Journal of Dental Sciences*. 2010; 2 (4): 12-14.
4. Bolton WA. The clinical application of a tooth size analysis. *American Journal of Orthodontics*. 1962; 48: 504-529.
5. Saini SG, Kahlon SS, Boparai CDS, Padda HK, Bhinder NK, Mann HK. Bolton's ratio applicability on north Indian population. *Indian Journal of Comprehensive Dental Care (IJCDC)*. 2014; 4 (2): 443-447.
6. Oktay H, Ulukaya E. Intermaxillary tooth size discrepancies among different malocclusion groups. *Eur J Orthod*. 2010; 32 (3): 307-312.
7. Profitt WR, Fields HW, Sanier DM. *Contemporary orthodontics*. 5th edition. Elsevier; 2012. pp. 181-185.
8. Wedrychowska-Szulc B, Janiszewska-Olszowska J, Stepień P. Overall and anterior Bolton ratio in Class I, II, and III orthodontic patients. *Eur J Orthod*. 2010; 32 (3): 313-318.
9. Paredes V, Gandia JL, Cibrian R. Do Bolton's ratios apply to a Spanish population? *Am J Orthod Dentofacial Orthop*. 2006; 129 (3): 428-430.
10. Pizzol KC, Goncalves JR, Santos-Pinto AD, Peixoto AP. Bolton analysis: an alternative proposal for simplification of its use. *Dental Press J Orthod*. 2011; 16 (6): 69-77.
11. Ricci ID, Scanavini MA, Kaieda AK, Rosário HD, Paranhos LR. Bolton ratio in subjects with normal occlusion and malocclusion. *Braz J Oral Sci*. 2013; 12 (4): 357-361.
12. Rao GP. Bolton's norms for Hyderabad population. *Annals & Essences of Dentistry*. 2012; 4 (3): 70-79.
13. Fernandes TMF, Sathler R, Natalicio GL, Castanha Henriques JF, Pinzan A. Comparison of mesiodistal tooth widths in Caucasian, African and Japanese individuals with Brazilian ancestry and normal occlusion. *Dental Press J Orthod*. 2013; 18 (3): 130-135.
14. Subbarao VV, Regalla RR, Santi V, Anita G, Kattimani VS. Interarch tooth size relationship of indian population: does Bolton's analysis apply? *J Contemp Dent Pract*. 2014; 15 (1): 103-107.
15. Lee SJ, Ahn SJ, Lim WH, Lee S, Lim J, Park HJ. Variation of the intermaxillary tooth-size relationship in normal occlusion. *Eur J Orthod*. 2011; 33 (1): 9-14.
16. Jóias RP, Velasco LG, Scanavini MA, de Miranda AR, Siqueira DF. Evaluation of the Bolton ratios on 3D dental casts of brazilians with natural, normal occlusions. *World J Orthod*. 2010; 11 (1): 67-70.
17. Bootvong K, Liu Z, McGrath C, Hägg U, Wong RK, Bendeus M, Yeung S. Virtual model analysis as an alternative approach to plaster model analysis: reliability and validity. *Eur J Orthod*. 2010; 32 (5): 589-595.
18. Abizadeh N, Moles DR, O'Neill J, Noar JH. Digital versus plaster study models: How accurate and reproducible are they? *J Orthod*. 2012; 39 (3): 151-159.
19. Stevens DR, Flores-Mir C, Nebbe B, Raboud DW, Heo G, Major PW. Validity, reliability, and reproducibility of plaster vs digital study models: comparison of peer assessment rating and Bolton analysis and their constituent measurements. *Am J Orthod Dentofacial Orthop*. 2006; 129 (6): 794-803.

Mailing address:
C.D. Raúl Alejandro Aude Díaz
E-mail: raul_aude@hotmail.com